METHOD AND BURNER FOR ROTARY KILNS

The present invention relates to a method of and a burner for generating a flame by means of the burner in a combustion zone of a rotary kiln.

Rotary kilns are typically used for treating various solid substances, especially when the treatment requires high temperature. Also typically, the treatment processes are endothermic, i.e. they require introduction of external heat into the kiln from outside of the kiln. Some examples of this kind of processes are e.g. reduction of oxidized ores and oxided concentrates and calcination of various compounds, such as combustion of clinker and lime. Treated material exiting the kiln is often hot and in order to improve heat economy, the heat therein is recovered e.g. by means of preheating the combustion air being introduced into the kiln.

Heat sources utilized in the kilns include liquid, gaseous and solid fuels, such as oil, natural gas and carbon dust. The burner is attached to the hot end of the kiln. Usually the burner has the construction of a multi-passage tube introduced through the end of the kiln via an opening arranged therein. The discharge end of the burner extends into the kiln to a location, which is optimal in view of both fuel combustion and heat transfer, which location depends on requirements set by the process practiced in the kiln. In some cases, the burner tube may extend only to the level of the inner surface of the burner end, but it may also extend several meters into the kiln. The burner tube is provided with passages for fuel (fuels) and combustion air, possibly also for additives necessary for the operation of the process.

Especially in treatment processes producing a hot product (clinker, lime, so-called lime sludge), the heat therein is recovered by transferring it into combustion air required in the firing of the fuel used in the process. In such a case, this air (so-called secondary air) is usually directed into the kiln by-passing the burner, and only so-called primary air is directed through the burner, which primary air is necessary for igniting, stabilizing (maintaining a constant ignition point) and forming of the flame. The proportion of primary air varies depending on individual burners and applications, but most typically it is 10-40 % of the total volume of combustion air. The primary air is directed to the burner in order to ensure controlled ignition of the fuel and a

constant ignition point (stabilizing of the flame) and to achieve a controlled form of the flame in the kiln. The primary air is led to the burner via a fan of its own.

However, the present primary air arrangements do not always provide for the desired results in view of both flame control and heat economy of the kiln. Moreover, the ever more exacting environmental requirements set increasingly tight limits to nitrogen oxides emissions. For example, reducing the amount of primary air typically results in a decrease in nitrogen oxide emissions, but at the same time complicates controlling the form of the flame, as well as adjusting the center of combustion. These, in turn, are factors, which have an effect on e.g. the heat economy of the process. The object of the present invention is to provide a method and a burner for more efficient controlling of combustion in a rotary kiln, such as a lime kiln, at the same time resulting in decreased detrimental emissions, e.g. nitrogen oxide emissions, compared to prior art systems.

The characteristic features of the present invention are disclosed in the appended claims. The invention is essentially based on the use of flue gas from a gas turbine instead of air as the source of primary air. Thus, a primary air fan has been replaced by a gas turbine.

In known burners, primary air is introduced at an overpressure of a few kPa, which primary air is un-preheated or slightly preheated, typically having a temperature of e.g. 150-200 °C. Air is known to contain oxygen in the amount of about 21% of its volume. In the new burner, gas exiting the turbine and entering the burner tube most often has an oxygen content of 15-16% and a temperature of 400-800°C, depending on the capacity of the turbine and pressure loss of the burner tube.

The object of the exhaust gas of the gas turbine is just the same as the object of air introduced by means of a primary air fan, but in the burner arrangement according to the invention the amount of air introduced to the ignition is clearly smaller than in known burners and with smaller flow volumes of oxygen and gas, typically only 4-10% of the total amount of combustion air. The fuel flow required by a gas turbine is very small compared to the main fuel flow, usually only a few percents.

A characteristic feature of the burner is that multiple various fuels may be burned therein simultaneously, even if they represent all three forms, e.g. solid, liquid and gaseous forms.

The invention may preferably be applied in lime sludge kilns, lime kilns and cement kilns.

Other air required in the kiln in addition to primary, such as secondary air, bypasses the burner. Typically the secondary air is heated by causing it to contact with the material combusted in the kiln.

The present invention is explained in more detail with reference to the appended Figures, in which
Fig. 1 represents a preferred burner arrangement according to the invention, and
Fig. 2a and 2b represent a second preferred burner arrangement according to the invention.

The construction and implementation principle of the burner is illustrated in Figure 1. The burner is formed of a tube 4, which extends into the kiln via an opening in the end wall 8 of the kiln. Exhaust gas from a gas turbine, i.e. primary air is led to the discharge end of the burner via the burner tube. Fuel, e.g. heavy oil, may be introduced conventionally by leading it from line 12 by means of a tube 3 (burner lance) of its own into a nozzle located in the discharge end 13 of the burner tube 4. A conventional embodiment comprises arranging it concentrically inside the burner tube so that it is surrounded by primary air, but other construction solutions are also possible. Depending on the quality of the fuel, it may also be fed into the forward end of the burner tube, in which case it will be mixed into primary air flowing in the tube and inflame in the formed mixture.

According to the invention, a gas turbine is connected to the burner, said gas turbine comprising a compressor 1, wherein air is led and a combustion chamber 2 and turbine 11 connected thereto. Fuel in line 9, such as natural gas or oil, and air from the compressor, are led into the combustion chamber 2, the flue gases (i.e. primary air) from which combustion chamber are led via the turbine 11 rotating the

compressor. The power requirement of the compressor 1 from the turbine 11 for generating the pressure needed in the combustion chamber is so small that the temperature decrease of the gas in the turbine is usually only 50-100 °C.

A characteristic feature of the burner arrangement is that gas (primary air) generated in the combustion chamber 2 and exiting the gas turbine is fed via a short connecting tube 7 into the actual burner tube 4. The connecting tube 7 is most suitably constructed so that it is connected to the burner tube 4 outside the burner end 8 of the kiln.

The gas turbine unit with its combustion chamber is relatively light weighted. It may be positioned separate from the burner tube, if desired, but preferably the burner tube, gas turbine unit and the connecting tube between them are integrated so that the gas turbine unit is supported to the burner tube via the connecting tube and, if needed, additional supports. An advantage of this kind of unit formed of the gas turbine and burner tube connected together is that its position in relation to the kiln may be changed. This also has an effect on the operation of the kiln: The burner tube is not always located in the direction of the longitudinal axis of the kiln, but it is typically inclined in the direction of the material bed to be treated, in order to intensify heat transfer from the flame to the bed. A fixed connection is preferable also constructionally, as the connection between the gas turbine and the burner tube is effected with a stationary connecting tube instead of using a flexible hose, which has to stand temperatures up to 800 degrees of Celsius, when necessary. A possibly needed cooler fan for the burner may be connected to the burner tube in a corresponding way.

According to Fig. 1, the gas from the turbine is fed into the burner tube 4 via an inclined connecting tube 7. In principle, the gas may be fed either tangentially from the side of the burner or axially via the end of the burner. The gas pressure loss in the burner tube (back pressure of the gas turbine) depends on the feed direction of the gas, so that the least loss is obtained via axial feed and greatest via tangential feed, thus the optimal construction has to be decided for each case individually.

Fig. 2a and 2b represent a burner arrangement, in which the gas from the gas turbine is led into the burner tangentially. In accordance with fig. 2a the burner com-

prises a burner lance 23, a casing tube 30 for the burner lance, if needed, a burner tube 24 and a cooling air housing 25. In this embodiment the burner tube 24 comprises a cyclone part 32, which is connected to the straight part 24 of the burner tube via a cone 26. Fuel is fed into the burner lance 23 from line 33. The gas from the gas turbine is introduced into the cyclone part 32 via a connecting tube 27, which connects the burner tube and the gas turbine and is attached tangentially to the cyclone part 32. The end wall of the kiln is marked with reference numeral 28.

Fig. 2b shows as a cross sectional view via line A-A of Fig. 2a the connection of the burner tube to the gas turbine. The gas turbine comprises a compressor 21, a combustion chamber 22 and a turbine 31. From the gas turbine the gas is led into the cyclone part 32 of the burner tube via connection tube 27, which is tangentially connected to the cyclone 32. Fuel is introduced into the combustion chamber via line 29.

The amount of ignition energy at the discharge end of the burner may be increased, if needed, by means of so-called intermediate combustion. Normally the burner tube is dimensioned so that the fuel fed therein cannot burn in the tube, but inflames only when the mixture is discharged from the burner into the kiln. Intermediate combustion is enabled by providing the burner tube with a zone, in which the flow speed of primary air is reduced to be lower than the propagation speed of the flame front by locally increasing the cross-sectional flow area of primary air. A preferred method of implementing intermediate combustion is to arrange the zone in the front end of the burner tube and led the exhaust gas from the gas turbine into the burner tube tangentially so that a cyclone-shaped intermediate burner is formed in the front end of the burner tube, as shown in Fig. 2a and 2b. This way, the temperature of the gas may be increased to be even more than 1000 degrees centigrade, if necessary. The fuel necessary for the temperature increase is usually fed into the connecting tube 7 between the gas turbine and the burner tube via line 10 in Fig. 1 and into the connecting tube 27 in Fig. 2b. The space required for intermediate combustion does not necessarily need to be located in the front end of the burner tube, but may be arranged in another location therein.

As the exhaust gas from the gas turbine has a temperature of several hundred degrees (400-800°C), the portion of the burner located inside the kiln tends to become

hotter than when using cooler primary air. For this reason, in the arrangement according to the invention, the burner tube is preferably cooled. According to the principal construction illustrated in the figures, the burner is provided with a concentrical outer housing 5 and cooling air is introduced between the housing and the actual burner tube 4 by means of a fan 6, which air exits via an annular slot between the tubes into the kiln (flame). A typical amount of cooling air is only 1–3% of the total combustion air flow. In individual objects, thermal insulation around the burner tube may be provided for increased protection.

By means of a burner according to the invention, the nitrogen oxide level can be reduced compared to using burners operating with air. The most important way to minimize the emission level is considered to be decreasing the amount of primary air (primary oxygen) and fastening the temperature increase in the flame after ignition, due to increased amount of ignition energy. Fast burning results in oxygen deficit in the flame and the combustion zone of the kiln, due to which thermal NO is mostly generated via OH radicals, which react to NO remarkably slower than free oxygen. The oxidation of nitrogen contained in the fuel to NO reduces as the oxygen content decreases, while the reduction of NO to molecular nitrogen increases.

Compared to present rotary kiln burners, the new solution also provides for better controllability of the flame in view of both the form of the flame and the rate of combustion. The latter is regulated by the capacity of the gas turbine, which affects the volume of exhaust gas flow from the turbine and the temperature of the flow. The combustion velocity also has an effect on the height of the flame and the burning temperature, and further the heat transfer from the flame to the material being processed in the kiln.

The burner also provides for a larger power adjustment zone than present rotary kiln burners. Stable combustion is possible even at very low power, because an amount of energy corresponding to the full capacity of the gas turbine may in the best case be introduced into the burner as ignition energy, simultaneously maintaining the main feed of fuel at a very low level without causing the burner to go out.